Applicant name: Michelle Baker, Department of Biology and the Ecology Center, Utah State University, Logan, Utah 84322-5305

Co-Applicant Names: Dave Epstein and Julie Kelso, Ecology Center, Utah State University

Project Title: Quantification and identification of sources of organic matter to the Jordan River

Agency or Business Name: Utah State University

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1. Estimated Project Costs:

Labor	$73,977
Materials & Equipment	$5,000
Administration	$53,535
Miscellaneous	$58,858 (travel and sample analysis)
TOTAL	$191,370

Other sources of project funding:

USU Ecology Center Grant	$4,000
iUtah	$55,872

Total project cost including other sources of funding: $251,242

Labor. Salary: USU requests $52,660 in salary compensation to conduct the proposed work. This includes a 0.5 FTE technician (rate=$44,000/year incremented at 3%/year COLA), and $8,000 for hourly wage student assistants. These funds would be dispersed over 2 USU fiscal years. Matching support includes 0.5 month for the principle investigator and 12 month 0.5 FTE graduate student assistant (both funded through the iUTAH EPSCoR project at an estimated $55,872 over 2 years).

Benefits: USU's benefit rates are calculated at 46% of technician salary, in year 1 and incremented by 0.5%/yr in year 2. Hourly wage benefits are charged at 8.2 and 8.3% of wages, in years 1 and 2 respectively. Total labor (salary and benefits) = $73,977 over 2 years.

Materials and Equipment. USU requests $2,500/year in field sampling equipment and supplies necessary to carry out proposed work. These funds will be used to purchase miscellaneous supplies and bioassay equipment.

Miscellaneous. Travel: USU requests $3,000/year for travel in support of the project. This would include motor pool vehicle rental to support travel between Logan and Salt Lake City for fieldwork and meetings with the Jordan River TAC. Travel costs also may be used to support up to $1,000 in hotel and per diem support for 2-3 people for up to 6 overnight trips to Salt Lake City for extended field work. Any residual would be used to help defray costs to sponsor conference participation for student and PI to present results at a conference such as WEAU or Society for Freshwater Science.

Analytical Costs: USU requests $52,858 to support analytical cost of dissolved and suspended organic matter samples collected from the thalweg manually or by ISCOs. This will support analysis of up to 624 samples (biweekly at 8 sites) for DOM and FPOM. The projected costs for the various analyses per sample are: DOM $12 (624 samples), FPOM/DOC isotopes ~$30-$35 ($10 C/N; ~$20 H; up to 312 samples for each FPOM and DOC), spectrofluorometry $10 (624 samples), radioisotopes $525 (~18 samples). $4000 is available as match to augment analytical costs from a grant to Julie Kelso (USU graduate student) from the USU Ecology Center.

Administration. USU's federally negotiated facilities and administration rate is 38.84% of direct costs (except direct cost of subawards >$25K, equipment >$5K, tuition, and participant support costs, none of which are applicable here). Given that there was no documentation in the request for proposals that administrative costs were restricted to a value less than 38.84%, we applied that rate here.

2. This project would benefit the natural environment in the Jordan River, an ecosystem that drains into the Great Salt Lake, and is in close proximity to Willard Bay State Park. The project would help identify sources of problematic organic matter to the river, thereby having social benefits if such sources can be mitigated in future phases of the Jordan River TMDL. In terms of size and scope, solving water quality issues on the Jordan River would impact much of the state of Utah, at least in the sense that much of the state's population lives in the watersheds draining to the Jordan River. The project leverages nearly 22% of funds needed to carry out the proposed work.

Violations of Utah water quality standards have resulted in the Jordan River's listing as an impaired water body on the State's 303(d) list of impaired waters. A Total Maximum Daily Load (TMDL) study (Cirrus Ecological Solutions 2011) was initiated and focused on lower reaches of the river, from Farmington Bay to 2100 south, that currently do not support the Class 3B aquatic life designated use as a result of low DO concentrations. Previously collected data and outputs from a QUAL2Kw model identified excess loads of organic matter (OM) as the primary cause of low DO concentrations in the lower Jordan River (Cirrus Ecological Solutions 2011).

In 2012 the Utah Division of Water Quality collaborated with The Baker Lab at Utah State University to complete a preliminary organic matter (OM) budget for

the Jordan River. The results of the OM budget study identified two "problem reaches" (between 7800 South to 5400 South and 3300 South to 2300 South, Figure 1) where OM transport, specifically dissolved organic matter (DOM) and fine particulate organic matter (FPOM) increased dramatically (Figure 2). The cause or source of increased OM transport in these reaches remains to be identified. Possible sources include terrestrial organic matter from soil and leaf leachates, instream primary production, or anthropogenic sources including urban runoff (e.g. stormwater catchment basins) and wastewater treatment effluent. The findings have illustrated the need for future data collection to better understand the primary sources, transport, and transformation of problematic OM within the Jordan River and Great Salt Lake watershed. The project proposed here aims to chemically characterize FPOM and DOM in order to identify the sources and decomposition potential of these materials. This critical information will inform the state's ongoing efforts to reduce OM loads and increase DO concentrations.

We propose to continue to monitor the identified problem reaches in addition to Mill Creek, a significant tributary to the Jordan River and expected source of high OM inputs to the 2300 South reach. Sampling in Mill Creek will include above and below stormwater catchment basins, as well as below the Central Valley Water Reclamation Facility. We will also monitor the upstream and downstream limits of the Jordan River (Utah Lake outflow and Cudahy Lane) to complete our understanding of water quality changes from the most upstream source point to the downstream compliance point (Figure 1). A secondary aim of the project is to measure the rate of decomposition of the various types of organic matter found in the Jordan River. Isolating which size class of OM (FPOM and DOM), and what sources result in the greatest consumption of DO will inform a focused and efficient effort to mitigate the appropriate loads of organic matter to the Jordan River.

We will measure water flow continuously using stage recorders and stage-discharge relationships developed as part of the 2012 study. Samples will be collected for FPOM and DOM approximately bimonthly and during storms. In addition to measuring the quantity of OM in each size fraction, we will measure stable isotope composition of H, C and N in the organic matter. Stable isotope ratios in samples will be compared to potential sources (e.g. terrestrial catchment basin material, algae) using end member mixing models to identify sources of FPOM and DOM. Preliminary data suggests that FPOM is primarily composed of biofilm, macrophytes and/or material stirred up from the bottom of the river (FBOM) and the carbon component of DOM may be a mix of terrestrial catchment basin material, algae and/or macrophytes (Figure 3). DOM will also be optically characterized using spectrofluorometry to parse out potential sources. Fractions of FPOM and DOM will be incubated with bacteria from the lower Jordan River to estimate potential decomposition and oxygen consumption rates.

3. Project Timeframe and Milestones

July 2014……..Funding start

July 2014……..Project commencement meeting

July–August 2014……Hire student and staff

July–September 2014……..Order equipment

July-September 2014……Finalize protocols

October 2014 – September 2015……..Sample collection

October 2014 – December 2015……Sample analysis

December 2014 – March 2016……Data analysis

June 2016……..Final report draft

September 2016……..Final report

4. The Jordan River flows 82 km from Utah Lake to the Great Salt Lake (Figure 1). The majority of project activities will take place on the Jordan River from South Jordan to North Salt Lake City, UT. The area enhanced by this project includes the entire Jordan River, the Jordan River Parkway, Farmington Bay and the southern portion of the Great Salt Lake. The Great Salt Lake covers on average 4,400 km^2 and receives inflows from only three tributaries including the Jordan River. In addition to directly investigating OM loads to the Great Salt Lake from the Jordan River, this study would characterize OM loads from Mill Creek informing the potential contribution of OM from tributaries that drain the Wasatch mountain range, the eastern boundary of the Salt Lake valley.

Improved water quality in the Jordan River would result in improved water quality conditions in the Great Salt Lake, as the Jordan River is one of its main tributaries. Other areas potentially enhanced by this study include the Jordan River Parkway, which parallels the length of the river in the form of a bike path, green and park spaces, and outdoor education facilities. Protocols developed as part of this project will be transferrable to other Great Salt Lake tributaries such as the Bear River, which directly drains into Willard Bay.

5. This project is aimed at improving water quality conditions in the Jordan River and The Great Salt Lake. Currently poor water quality in the Jordan River and portions of The Great Salt Lake (Farmington Bay) is a result of homogenized physical habitat, and high nutrient and organic matter inputs which result in low DO concentrations due respiration by autotrophs and heterotrophs, as well as decomposition of organic material. Throughout the summer lower portions of the river can have mean monthly DO concentrations as low as 2 mg L^{-1}, which is unhealthy and even lethal to aquatic organisms such as invertebrates and fishes. A large variety of animals, including resident and migratory waterfowl and

shorebirds, depend on the Jordan River and Great Salt Lake for breeding habitat and food resources. Improved water quality in the Jordan River will also encourage population recovery for native species and greater ecosystem health for the river and associated wetland habitats that surround the Great Salt Lake.

6. In 2009 the Utah Department of Environmental Quality Division of Water Quality began Phase I of a TMDL water quality study. Partners included Cirrus Ecological Solutions and Stantec Consulting as well as input from a Technical Advisory Committee. The primary goal of the TMDL study was to focus on possible sources of loading and potential load allocations of organic matter, the identified pollutant of concern. This study will continue the work initiated by the TMDL and initiate further investigation into improving water quality upstream of the Jordan River (Utah Lake) and downstream in the Great Salt Lake.

7. Citizens of the Salt Lake Valley use the Jordan River for recreation and outdoor education as well as aesthetic enhancement of private and public property along the river. Currently multiple reaches along the river do not satisfy specified designated uses including Class 2B secondary contact recreation, Class 3A cold water aquatic life, and Class 3B warm water aquatic life as a result of high temperatures, Total Dissolved Solids, E-coli concentrations and low DO concentrations. Restoration practices that focus on reducing or mitigating OM loads in the Salt Lake valley could improve habitat for warm and cold water aquatic life.

The Jordan River Parkway is an urban park that potentially serves up to a million residents in the Salt Lake Valley. Along the Jordan River parkway are four nature centers and over 30 state, county and municipal parks. School districts throughout the valley use green space along the Jordan River for outdoor education opportunities and to educate citizens who are concerned about severe water quality problems associated with Utah Lake, the Jordan River and The Great Salt Lake. A restored Jordan River would benefit frequent users of the river including anglers, birdwatchers, joggers, equestrians and boaters. Improved water quality would attract more visitors to the river and associated wetlands of the Great Salt Lake.

8. This project involves fieldwork along an approximately 35 km section of the Jordan River. The majority of the 8 sample locations have public access and permission has already been obtained to access the river and the river parkway from the Department of Water Quality and Salt Lake County to access sites by vehicle. FPOM and DOM samples would be collected using protocols developed by the Baker Lab and analyzed for organic matter content, stable isotopes and spectrofluorescence at approximately biweekly intervals.

9. Numerous projects of this scope have been implemented by the Aquatic Biogeochemistry Laboratory at Utah State University under the leadership of Professor Michelle Baker (see attached “Results of Prior Support”). Currently, we are completing the final report for the Jordan River Organic Matter Budget study

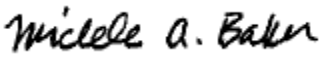
prepared for the Utah Division of Water Quality, which was the preliminary research informing this proposal.

10. The aim of the project is to gather sufficient information to inform management changes to the Jordan River watershed. Our previous work has begun to inform managers as to where the "problem" reaches are along the Jordan River and this proposed project will provide the missing information needed to help restore the river. Specifically we aim to identify the sources of problematic organic matter in the river and measure the variation in decomposition potential of different sources of organic matter. Knowledge of which types of organic matter result in the greatest consumption of dissolved oxygen and the sources of these materials will inform management decisions aimed at reducing OM input into the river. After data are collected and interpreted, there would be no need for future maintenance of the work described herein. Raw data will be provided to DWQ and its consultants for future use in TMDL efforts.

11. This project is an outgrowth of prior collaboration with the UDWQ, Farmington Bay Jordan River Water Quality Commission, and Dr. Ramesh Goel of the University of Utah.

Supplemental documents include 3 figures and a statement of prior support describing projects of similar scope.

Thank you for considering our proposal,

Signature (applicant) :  May 5, 2014

Michelle A. Baker

Signature (coapplicants) : 

Dave Epstein May 5, 2014

Julie Kelso May 5, 2014

Figure 1. A map showing the location of the project; the Jordan River flowing south out of Utah Lake and into The Great Salt Lake. Planned sampling locations are shown with the Below UL site the furthest upstream and the Cudahy Ln the furthest downstream.

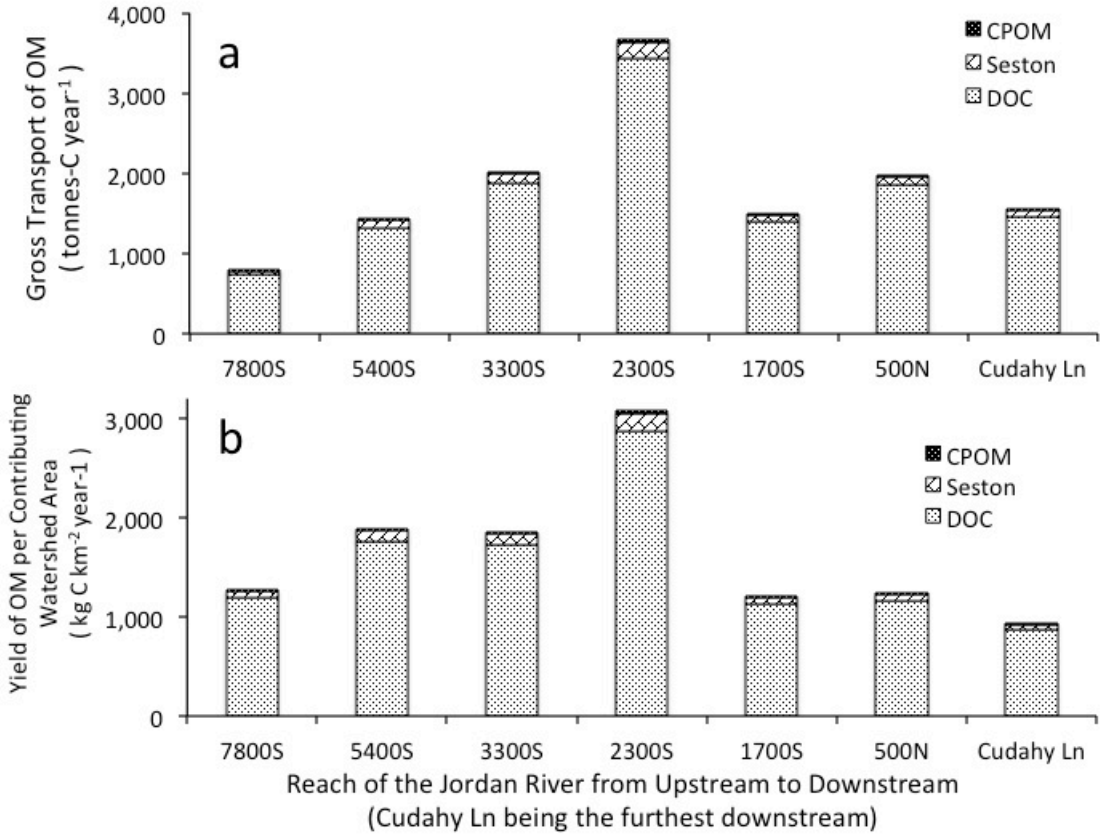


Figure 2. Transport of organic matter (OM, the fraction that is carbon) through seven reaches of the Jordan River. A steady increase in gross OM transport was observed with distance downstream (a) until 2300S, downstream of which the majority of the river is diverted into a Surplus Canal. Comparing the yield (transport per contributing watershed area) of OM at each site (b) clarifies that the majority of the OM inputs were in the 7800S-5400S and 3300S-2300S reaches.

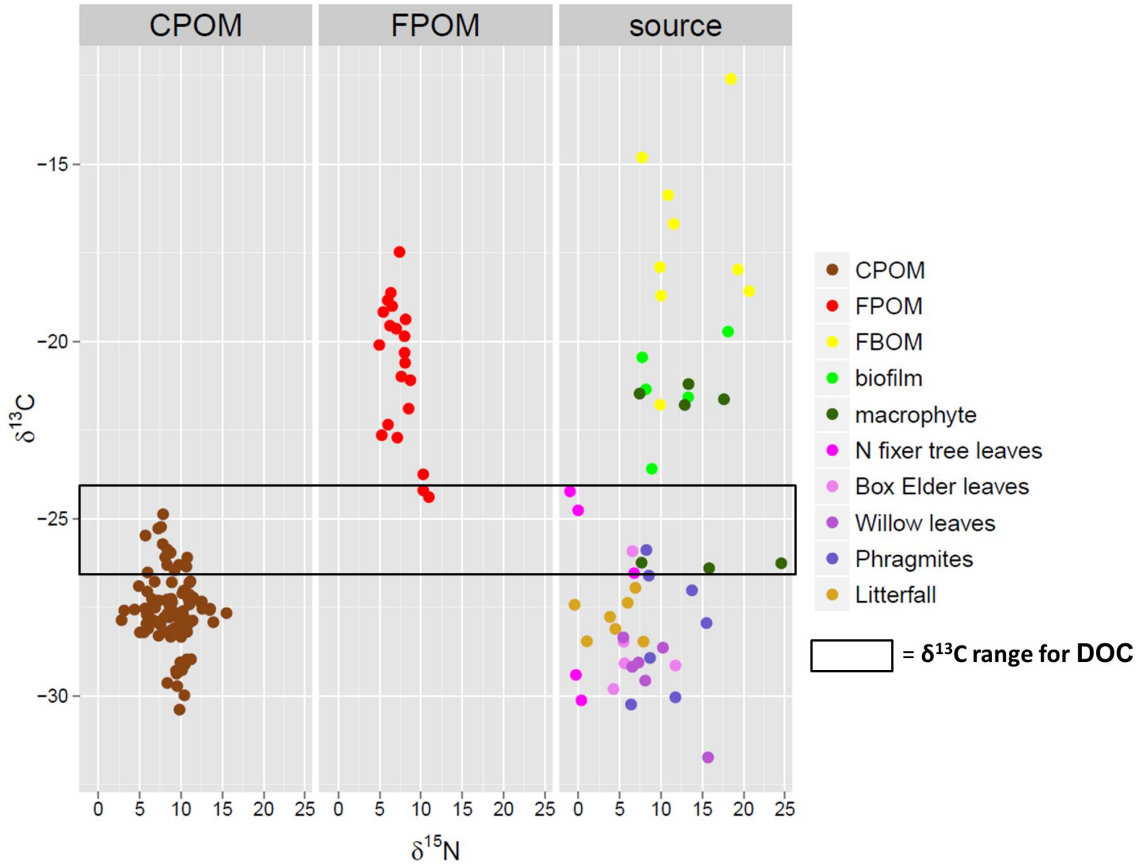


Figure 3. The natural abundance of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes for Coarse Particulate Organic Matter (CPOM; left panel), and Fine Particulate Organic Matter (FPOM; right panel) measured in the water column at 7 sites along the Jordan River. The range of $\delta^{13}C$ signatures of Dissolved Organic Carbon (DOC) is represented by the height of the black box. The $\delta^{13}C$ and $\delta^{15}N$ values of potential sources of organic matter such as Fine Benthic Organic Matter (FBOM), biofilm, macrophytes, riparian leaves, and senesced leaf litter in autumn are shown in the right panel in comparison to the isotopic values of CPOM, FPOM and DOC.

Baker Results of Prior Support 2009-2014

National Science Foundation DEB 09-22153; $167,647; 8/1/09-7/31/14

Collaborative Research: Using empirical and modeling approaches to quantify the importance of nutrient spiraling in rivers

We measured nutrient and carbon spiraling in 15 rivers along a gradient of biophysical conditions (land use, nutrients, suspended sediments) in North America, and interpreted these data in the context of published data sets for streams, and synthesized these in river network models. We found that rates of nutrient removal in inland rivers was equivalent to rates in small streams, and in a watershed context, the role of rivers in mitigating downstream transport of nutrients was more important than in headwaters, owing to greater residence time of water in river segments. The project contributed to the training of 9 undergraduate students, 1 Master's student, 2 PhD students, and one postdoc.

Hall, R.O., M.A. Baker, E.J. Rosi-Marshall, J.L. Tank, and J.D. Newbold. 2013. Solute specific scaling of inorganic nitrogen and phosphorus uptake in streams. Biogeosciences doi:10.5194/bg-10-1-2013.

Hall, R. O., J. L. Tank, M.A. Baker, E.J. Rosi-Marshall, and E.R. Hotchkiss. In review. Metabolism, gas exchange, and carbon spiraling in rivers. Ecosystems.

Hotchkiss, E.R., R.O. Hall, M.A. Baker, E.J. Rosi-Marshall, and J.L. Tank. In press. Modeling priming effects on microbial consumption of dissolved organic carbon in rivers. DOI: 10.1002/2013JG002599.

Reisinger, A.J., J.L. Tank, E.J. Rosi-Marshall, R.O. Hall, and M.A. Baker. In preparation. The role of pelagic nutrient removal along river networks in contrasting landscapes. Biogeochemistry.

Several others in preparation

National Science Foundation OIA 12-08732; $20,000,000; August 1, 2012-July 31, 2017

iUTAH- Urban transitions and aridregion hydro-sustainability

iUTAH is a state-wide human and research infrastructure improvement effort dedicated to maintaining and improving water sustainability in Utah. Research supported by iUTAH examines the interactions and feedbacks among water, people, and the environment. The project aims to understand biophysical and social drivers of the water cycle in the urbanizing Wasatch Front. The project also explores potential adaptive solutions water sustainability issues including alternative water management strategies, urban planning and design, and the use of green infrastructure to enhance and protect ecosystem services.

No publications to date, but 14 publications that have received primary or partial support from iUTAH are submitted for peer review.

iUTAH researchers have deployed an environmental observatory, Gradients Along Mountain to Urban Transitions (GAMUT), that measures, in real-time, aspects of the water cycle in 3 watersheds with contrasting patterns of urban form and expansion of the urban footprint into lands originally developed for agriculture. Of particular relation to the proposed research is the measurement of FPOM and DOM quantity along Red Butte Creek, a tributary of the Jordan River. The provisional data from the GAMUT network is available online http://data.iutahepscor.org/mdf/gamut-network.